REMARKS/ARGUMENTS

Applicant would like to thank the Examiner for the careful consideration given the present application. The application has been carefully reviewed in light of the Office Action.

As a preliminary matter, applicant notes that the Examiner failed to acknowledge that **all** copies of the priority documents have been received in this National Stage application. Applicant respectfully requests that the Examiner acknowledge in the next Office action that all copies of the priority documents have been received. If all copies of the priority documents have not been received from the International Bureau, please contact Mr. Mike Neas at the PCT-help desk (571-272-3289) for assistance in retrieving copies of the documents.

The Examiner objected to the drawings "because reference character '2' has been used to designate a rotatable sonic element and an arc-shaped sonic element." See the outstanding Office action at page 2. The Examiner recommends that one of the elements be labeled as "2a." Applicant respectfully draws the Examiner's attention to application page 6 at lines 19-21, which recites, "an arc-shaped sonic element 2 is supported by an ultrasonic motor (M) 3 such as to enable back and forth rotation within oil 6 in a direction perpendicular to the arc direction." The arc-shaped sonic element shown in the drawings is rotatable. Therefore, the amendment recommended by the Examiner has not been made.

Applicant acknowledges the Examiner's suggested preferred layout for the specification.

The Examiner objected to the paragraph that begins at application page 8, line 7. Appropriate amendments have been made. The Examiner also objected to the title of the invention, which has been amended.

Claims 1 and 2 were rejected under 35 U.S.C. 112, second paragraph, for reciting the term "window." The Examiner is respectfully reminded that the requirement to distinctly claim means that the claim must have a meaning discernible to one of ordinary skill in the art. Only when a claim remains insolubly ambiguous without a discernible meaning after all reasonable attempts at construction should a claim be declared indefinite. If the language of the claim is such that a person of ordinary skill in the art could not interpret the metes and bounds of the claim so as to understand how to avoid infringement, a rejection of the claim under 35 U.S.C. 112, second paragraph, would be appropriate. See MPEP § 2173.02. Applicant submits that the term "window" as recited in claims 1 and 2 is readily understandable to one of ordinary skill in the art and has clear meaning in the pertinent art. In fact, the term "window" is recited over 60 times in the Ramamurthy reference (USPN 7,156,551) cited by the Examiner, and is explicitly recited in its claims (see claims 1, 3, 4, 6 and 14). Because the term "window" is readily understandable to one of ordinary skill in the art and has clear meaning in the pertinent art, the rejection of claims 1 and 2 under 35 U.S.C. 112, second paragraph is improper. Applicant respectfully requests that the rejections be withdrawn.

Claims 1-4 were rejected under 35 U.S.C. 102(e) as being anticipated by Ramamurthy. Applicant has submitted a declaration under 37 CFR 1.131 establishing reduction to practice of the claimed invention prior to June 23, 2003, which is the earliest possible effective date of the Ramamurthy reference. The reduction to practice occurred after January 1, 1996 in Japan, a WTO member country, but prior to the earliest possible effective date of the Ramamurthy reference. The present application claims priority to Japanese patent application 2003-191700, which was filed on July 4, 2003. As can be seen from the declaration, a substantially complete

draft of JP 2003-191700 was prepared and transmitted to the assignee of the present application, Matsushita Electric Industrial Co., Ltd, on June 20, 2003. The only difference between the draft application and the application filed as JP 2003-191700 is the addition of claim 3 in the filed application. Applicant submits that the invention claimed in the present application is completely disclosed in the draft application of June 20, 2003. Clearly, the invention claimed in the present application was invented in Japan prior to earliest possible effective date of the Ramamurthy reference, and the rejections under 102(e) should be withdrawn.

Further, claim 1 recites in part, "calculating the sound velocity of ultrasonic waves based on the difference between the reflex time of ultrasonic wave reflected from the inner surface of a window in contact with a test subject and the reflex time of ultrasonic wave reflected from the outer surface of the window and the thickness of the window." Ramamurthy does not teach or suggest a difference between a reflex time of ultrasonic wave reflected from the inner surface of a window in contact with a test subject and the reflex time of ultrasonic wave reflected from the outer surface of the window. Ramamurthy merely teaches a time delay *after a transmit event* and using time-of-arrival to estimate window temperature (10:17-19, 32-34). However, Ramamurthy is utterly silent with respect to calculating a sound velocity based on a difference between a reflex time of ultrasonic wave reflected from an inner surface of a window and a reflex time of ultrasonic wave reflected from an outer surface of a window. The Examiner does not address the noted limitations of claim 1 in the rejection and, therefore, provides no explanation of how the limitations could be taught or suggested by Ramamurthy. Applicant submits that Ramamurthy does not anticipate claim 1, and respectfully requests that the rejection

be withdrawn. Claim 3 depends from claim 1 and, therefore, claim 3 is not anticipated by Ramamurthy.

Claim 2 recites, "calculating the sound velocity of ultrasonic waves based on the reflex time of ultrasonic wave passing through fluid wherein sonic elements vibrate and reflected from the inner surface of a window in contact with a test subject and the thickness of the fluid." Ramamurthy does not teach or suggest calculating a sound velocity *based on a thickness of a fluid* wherein sonic elements vibrate. Ramamurthy teaches that "some transducer lens or window materials acoustically match well to water, gel or tissue" and that "vary [*sic*] little reflected signal is provided from the lens or window surface for such materials" (11:63-66). Ramamurthy also teaches that "a lower frequency excitation signal...is used to provide a larger reflection from the lens or window surface" (12:1-3). Additionally, Ramamurthy teaches, "variations in the lens or window surface reflection coefficient, such as caused by air versus gel or tissue contacting the lens or window, are removed or accounted for by using a curve fitting approach" (12:66-13:2). Applicant submits that the water or gel discussed in Ramamurthy does not teach or suggest "fluid wherein sonic elements vibrate," as required by claim 1. Further, Ramamurthy does not teach or suggest calculating a sound velocity based on a thickness of such a fluid. Applicant submits that Ramamurthy does not anticipate claim 2, and respectfully requests that the rejection be withdrawn. Claim 4 depends from claim 2 and, therefore, claim 4 is not anticipated by Ramamurthy.

Claim 1 was rejected under 35 U.S.C. 102(b) as being anticipated by Umemura. The Examiner admits that Umemura fails to teach a window, as recited in claim 1. As discussed above, the term "window" recited in claim 1 is not indefinite, is readily understandable to one of

ordinary skill in the art and has clear meaning in the pertinent art. Umemura does not teach or suggest a difference between a reflex time of ultrasonic wave reflected from the inner surface of a window in contact with a test subject and the reflex time of ultrasonic wave reflected from the outer surface of the window. Therefore, claim 1 is not anticipated by Umemura, and the rejection of claim 1 should be withdrawn.

In light of the foregoing, it is respectfully submitted that the present application is in condition for allowance and notice to that effect is hereby requested. If it is determined that the application is not in condition for allowance, the Examiner is invited to initiate a telephone interview with the undersigned attorney to expedite prosecution of the present application.

If there are any additional fees resulting from this communication, please charge same to our Deposit Account No. 16-0820, our Order No. 39088.

Respectfully submitted,
PEARNE & GORDON, LLP

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Date: August 1, 2007

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Fujii; Kiyoshi
Appln. No.	:	10/560,846
Filed	:	December 15, 2005
Title	:	ULTRASONOGRAPH
Conf. No.	:	2071
Art Unit	:	3768
Examiner	:	Helene Bor
Customer No.	:	00116
Docket No.	:	39088

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION UNDER 37 CFR 1.131

Sir:

This Declaration under 37 CFR 1.131 is filed along with supporting material and a response to the outstanding Office of April 20, 2007.

DECLARATION UNDER 37 CFR 1.131 ESTABLISHING PRIOR INVENTION

I, Kiyoshi Fujii, as inventor in the above-identified patent application, hereby declare as follows:

1. My citizenship, residence and post office address are as stated below, immediately beneath my signature.

2. All statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true.

3. In Japan, prior to June 23, 2003, I conceived and reduced to practice the ultrasonic diagnostic apparatus claimed in the above-identified patent application.

4. It is my belief that the whole invention as set forth in claims 1-4 of the above-identified patent application was in my possession prior to June 23, 2003.

5. A draft patent application disclosing the invention as set forth in claims 1-4 of the above-identified application was transmitted for review to Matsushita Electric Industrial Co., Ltd, assignee of the above-identified application, on June 20, 2003. The draft patent application is identical to Japanese patent application JP 2003-191700, filed July 4, 2003, and to which the above-identified patent application claims priority, with the exception that said draft patent application lacks claim 3 found in JP 2003-191700.

6. A copy of said draft patent application is attached as DOCUMENT 1.

7. An English language translation of said draft patent application is attached as DOCUMENT 2, along with the translator's verification statement.

I further declare that these statements were made with knowledge that wilful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such wilful false statements may jeopardize the validity of the application or any patent issuing thereon.

Inventor Name: Kiyoshi Fujii

Signature: Kiyoshi Fujii Date : July 18, 2007
K.F 2007/7/18

Country of Citizenship: Japan

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Kanagawa, Japan 230-0075

Attachments:

DOCUMENT 1 (13 pages)
DOCUMENT 2 (18 pages)

DOCUMENT 1

平成15年6月20日提出

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下記の出願依頼につきまして、出願予定原稿・図面(案)を作成致しましたので、ご検討の程、よろしくお願い申しあげます。

※依頼書未着につき知財単位、コードNo.依頼番号のご連絡、発明者住所氏名(依頼書)のご確認をお願い致します。

[依　頼] 依頼事業場 未着　依頼番号 未着

依頼書　☐ 受領済み　☑ 未着

[送付書類] 13 枚 (本状を含む)

[処理内容]
出願原稿　☐ 有　☑ 無
内容確認　☑ 確認した　☐ 確認しない
確認方法　☐ 電話・FAX 等　☑ 面接・検討会 等
内容補充　☑ 有　☐ 無
　☐ 若干修正
　☐ 大幅修正／クレーム再設計
　☐ 書き直し／新規事項追加
緊急処理　☐ 有　☑ 無
出願希望日　☐ 有 (　年　月　日)　☑ 無

ランク未指定です。

[特定料金]

依頼時ランク	ランク	請求項数	追加料金
	Aランク ・ Bランク	2	100,000

(追加料金は、外部特許事務所 費用算定基準('98.8.18)に基づき算定しております。)
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確認日	検印	検印	出願担当者
年　月　日			

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☐ 別紙又は下記の内容をご検討後、再度原稿を送付してください。

コメント

(社内使用欄)

出願予定原稿・図面が送付されてきましたので、至急 確認願います。

事務業務処理回答欄　回答期限日　年　月　日 (知的財産権グループ 必着)

確認日	発明者	確認日	知財担当者
年　月　日	印	年　月　日	印
修正 ☐ あり　☐ なし ☐ 別紙あり(　枚) ☐ 原稿中に赤で修正		修正 ☐ あり　☐ なし ☐ 別紙あり(　枚) ☐ 原稿中に赤で修正	
コメント		コメント	

【書類名】　特許願

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【あて先】　特許庁長官殿

【国際特許分類】　Ａ６１Ｂ　８／００

※ご確認下さい

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【包括委任状番号】　０００３２２２

【書類名】　明細書

【発明の名称】　超音波診断装置

【特許請求の範囲】

【請求項１】　被検体に接触するウィンドウの内面から反射された超音波の反射時間と前記ウィンドウの外面から反射された超音波の反射時間の差と、前記ウィンドウの厚みに基づいて超音波の音速を算出する音速算出手段と、

前記音速算出手段により算出された音速に基づいて前記ウィンドウの温度を算出する温度算出手段と、

前記温度算出手段により算出された温度に基づいて超音波出力を制御する超音波出力制御手段とを、

備えた超音波診断装置。

【請求項２】　音響素子が揺動する流体を通過して被検体に接触するウィンドウの内面から反射された超音波の反射時間と、前記流体の厚みに基づいて超音波の音速を算出する音速算出手段と、

前記音速算出手段により算出された音速に基づいて前記流体の温度を算出する温度算出手段と、

前記温度算出手段により算出された温度に基づいて超音波出力を制御する超音波出力制御手段とを、

備えた超音波診断装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】

本発明は、超音波プローブの被検体接触面温度を制御する超音波診断装置に関する。

【０００２】

【従来の技術】

超音波プローブの表面は患者に直接接触するので、患者の火傷などの障害を避けるために、表面は所定温度（例えば４３°Ｃ）未満になるように法的規制がある。従来例１としては、例えば下記の特許文献１、２に示されるようにプローブ

内に温度センサを設けて超音波出力を制御する方法が提案されている。また、従来例２としては、例えば下記の特許文献３に示されるように温度センサを設ける代わりに、プローブの印加電圧と表面温度の関係をあらかじめ測定しておき、表面温度が規制値を超えないようにプローブの印加電圧をソフトウエアやハードウエアにより制御する方法が提案されている。

【０００３】

【特許文献１】

特開平７－２６５３１５号公報（図１、段落０００８）

【特許文献２】

特開２００１－３２１３７７号公報（図１、段落００２６）

【特許文献３】

特開２０００－５１６５号公報（図１、段落００２０）

【０００４】

【発明が解決しようとする課題】

しかしながら、温度センサを用いた上記の従来例１では、温度センサの分だけ高価となるという問題点があり、また、温度センサの配置位置によっては被検体接触面温度であるプローブ表面温度を正確に測定することができないという問題点がある（課題１）。

【０００５】

また、ソフトウエアやハードウエアにより表面温度を制御する上記の従来例２では、ソフトウエアのバグや暴走、ハードウエアの故障により表面温度が規制値を超える場合があるという問題点がある。また、超音波を連続送信した場合、表面温度は実際にはプローブのウィンドウや内部の液体の比熱に応じて徐々に上昇し、急に規制値を超えないにもかかわらず、従来例２では、超音波出力を過度に低く設定しており、このため、超音波画像の感度が悪いという問題点がある（課題２）。

【０００６】

本発明は上記の課題１、２に鑑み、温度センサを設けることなく、また、超音波出力を過度に低く設定することなく被検体接触面温度を所定値以下に制御する

ことができ、ひいては低温火傷を防止することができる超音波診断装置を提供することを目的とする。

【0007】

【課題を解決するための手段】

本発明は上記目的を達成するために、被検体に接触するウィンドウの内面から反射された超音波の反射時間と前記ウィンドウの外面から反射された超音波の反射時間の差と、前記ウィンドウの厚みに基づいて超音波の音速を算出する音速算出手段と、

前記音速算出手段により算出された音速に基づいて前記ウィンドウの温度を算出する温度算出手段と、

前記温度算出手段により算出された温度に基づいて超音波出力を制御する超音波出力制御手段とを、

備えた構成とした。

上記構成により、被検体に接触するウィンドウの温度を検出することができるので、温度センサを設けることなく、また、超音波出力を過度に低く設定することなく被検体接触面温度を所定値以下に制御することができ、ひいては低温火傷を防止することができる。

【0008】

また、本発明は上記目的を達成するために、音響素子が揺動する流体を通過して被検体に接触するウィンドウの内面から反射された超音波の反射時間と、前記流体の厚みに基づいて超音波の音速を算出する音速算出手段と、

前記音速算出手段により算出された音速に基づいて前記流体の温度を算出する温度算出手段と、

前記温度算出手段により算出された温度に基づいて超音波出力を制御する超音波出力制御手段とを、

備えた構成とした。

上記構成により、流体とウィンドウの温度差がない場合にはウィンドウの温度を検出することができるので、温度センサを設けることなく、また、超音波出力を過度に低く設定することなく被検体接触面温度を所定値以下に制御することが

でき、ひいては低温火傷を防止することができる。

【０００９】

【発明の実施の形態】

以下、図面を参照して本発明の実施の形態について説明する。

図１（ａ）は、本発明の実施の形態に係る超音波プローブ１を側面から見た内部構成を示し、図１（ｂ）は超音波プローブ１を正面から見た内部構成を示している。図１において、超音波プローブ１は図２に示す超音波診断装置本体１０とケーブルを介して着脱自在に接続されている。超音波プローブ１の先端のウィンドウ５により外部と仕切られた内部には、円弧状の音響素子２が超音波モータ（Ｍ）３により円弧方向と直交する方向にオイル６内を往復回動可能に支持されている。超音波モータ３は駆動電力を図２に示す超音波診断装置本体１０から２相トランス（Ｔ）４を介して供給されて駆動される。そして、図２に示すように音響素子２の出力が超音波診断装置本体１０に送られて画像処理部１１により音響素子２の円弧方向と、走査方向と深度方向の３次元画像に処理され、この３次元画像がモニタ１３に表示される。

【００１０】

ところで、ウィンドウ５としてポリメチルペンテン、オイル６として１．３ブタンジュールの「温度－音速」の特性は、以下の表及び図３のグラフの通りとなる。

【００１１】

（表１）

	１０	２０	３０	４０° Ｃ
ウィンドウ５	１９８４	１９２９	１８７０	１８１０ｍ／ｓ
オイル６	１５８３	１５５５	１５２８	１４９８ｍ／ｓ

【００１２】

また、超音波プローブ１が被検体に接触していない状態で音響素子２から超音波パルスを出力すると、図４（ａ）に示すようにオイル６を通過してウィンドウ５の内面により反射され、オイル６を介して戻るので、出力から時間ｔ１の経過後に音響素子２により受信される。また、図４（ｂ）に示すようにウィンドウ５

を通過してウィンドウ５の外面により反射され、ウィンドウ５及びオイル６を介して戻るので、出力から時間ｔ２の経過後に音響素子２により受信される。

【００１３】

そこで、超音波診断装置本体１０内のメインシステム１４により、

ウィンドウ５の音速＝（ウィンドウ５の厚み×２）／（ｔ２－ｔ１）

を計測し、この計測した音速から図３に示すようなグラフを参照してウィンドウ５の表面温度を検出することができる。そして、この温度が既定値を超えている場合には超音波の出力を停止したり、低下させることができる。

【００１４】

また、この実施の形態のように、音響素子２を回動する３次元装置の場合には、オイル６が攪拌されてウィンドウ５とオイル６の温度にあまり差がないので、

オイル６の音速＝（オイル６の厚み×２）／ｔ１

を計測することにより、ウィンドウ５の表面温度を間接的に検出することができる。

【００１５】

ここで、「ウィンドウ５の厚み」や「オイル６の厚み」のばらつきにより測定温度に誤差が発生する。そこで、超音波プローブ１を組み立てた状態で超音波プローブ１ごとにウィンドウ５やオイル６の超音波伝搬時間をあらかじめ一定温度下で測定して記憶し、キャリブレーションを行うことにより、「ウィンドウ５の厚み」や「オイル６の厚み」のばらつきによる測定温度の誤差を軽減して、より精度の高い温度検出を行うことができる。

【００１６】

なお、上記の実施の形態では、音速、温度の検出を超音波診断装置本体１０側で行っているが、超音波プローブ１側で行うようにしてもよく、この場合には既存の超音波診断装置本体１０側にフェールセーフ機能を持たせることができる。また、上記の実施の形態では、３次元の超音波診断装置を例にしたが、２次元の超音波診断装置にも適用することができる。ここで、３次元の超音波診断装置において２次元モードでユーザが使用している状態（モータ３は停止状態）において温度が既定値を超えた場合には超音波の出力を停止、低下させないで、モータ

３を回転させてオイル６を撹拌させることにより温度上昇を抑制することができるので、高出力状態の時間を延ばすことができる。

【００１７】

【発明の効果】

以上説明したように請求項１に記載の発明によれば、被検体に接触するウィンドウの温度を検出することができるので、温度センサを設けることなく、また、超音波出力を過度に低く設定することなく被検体接触面温度を所定値以下に制御することができ、ひいては低温火傷を防止することができる。

また、請求項２に記載の発明によれば、流体とウィンドウの温度差がない場合にはウィンドウの温度を検出することができるので、温度センサを設けることなく、また、超音波出力を過度に低く設定することなく被検体接触面温度を所定値以下に制御することができ、ひいては低温火傷を防止することができる。

【図面の簡単な説明】

【図１】

（ａ）本発明に係る超音波プローブを側面から見た内部構成図

（ｂ）本発明に係る超音波プローブを正面から見た内部構成図

【図２】

本発明に係る超音波診断装置の一実施の形態を示すブロック図

【図３】

図１のウィンドウとオイルの「温度－音速」特性を示すグラフ

【図４】

（ａ）図１のウィンドウの内面による反射を示す説明図

（ｂ）図１のウィンドウの外面による反射を示す説明図

【符号の説明】

１　超音波プローブ

２　音響素子

３　超音波モータ（Ｍ）

４　２相トランス（Ｔ）

５　ウィンドウ

６　オイル

１０　超音波診断装置本体

１１　画像処理部

１３　モニタ

１４　メインシステム

図1

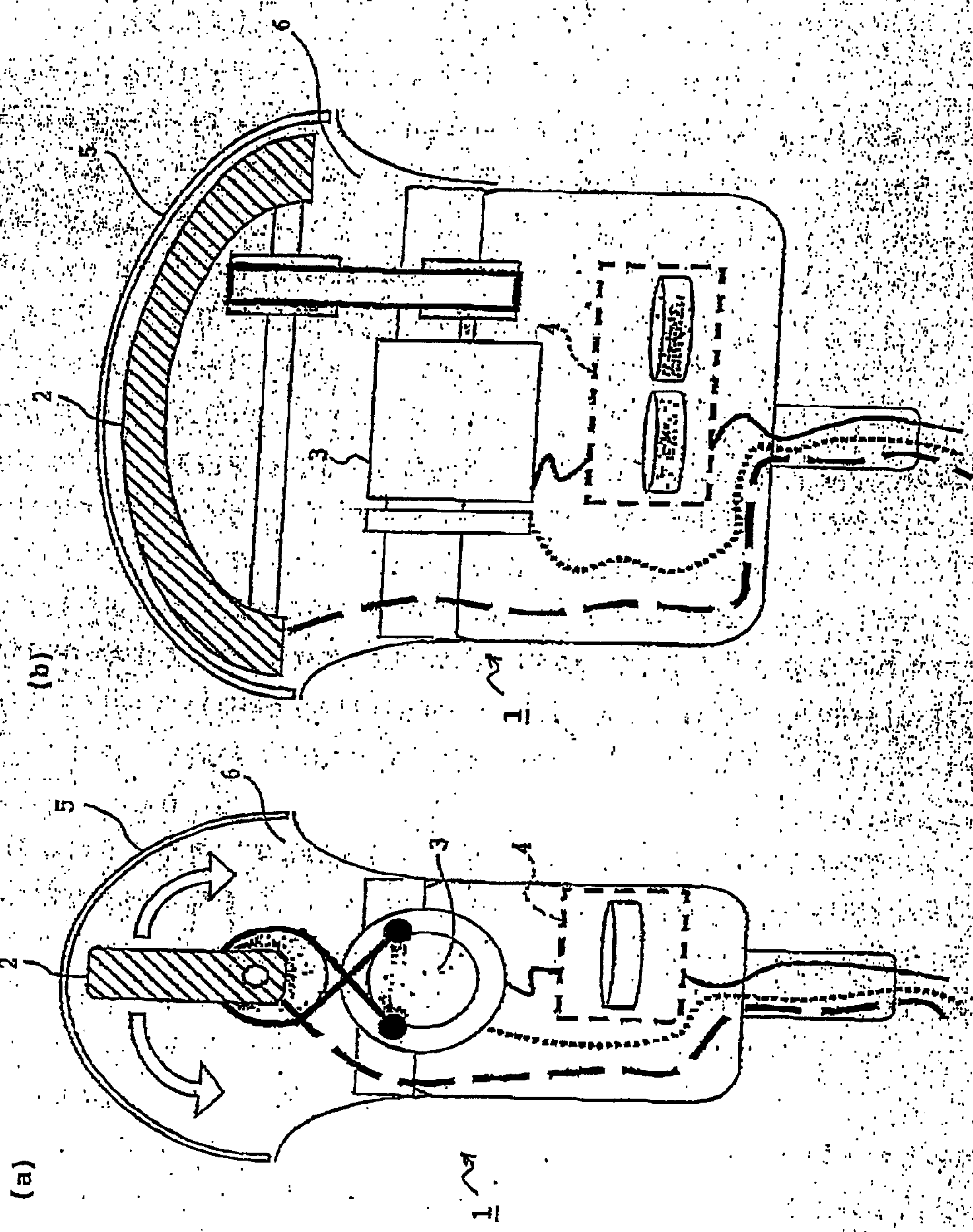
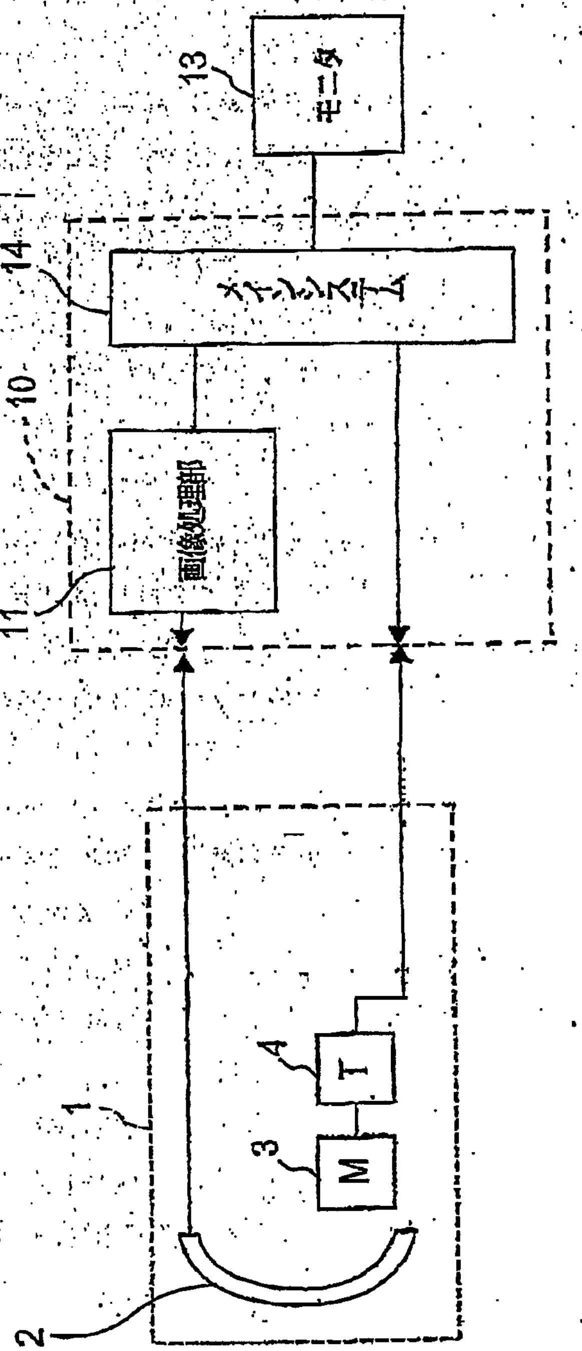
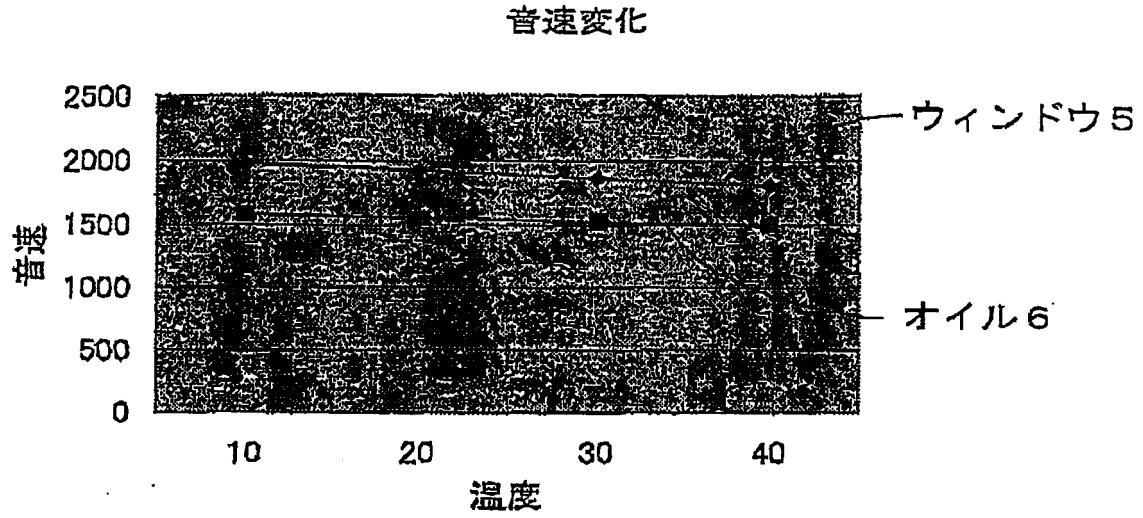


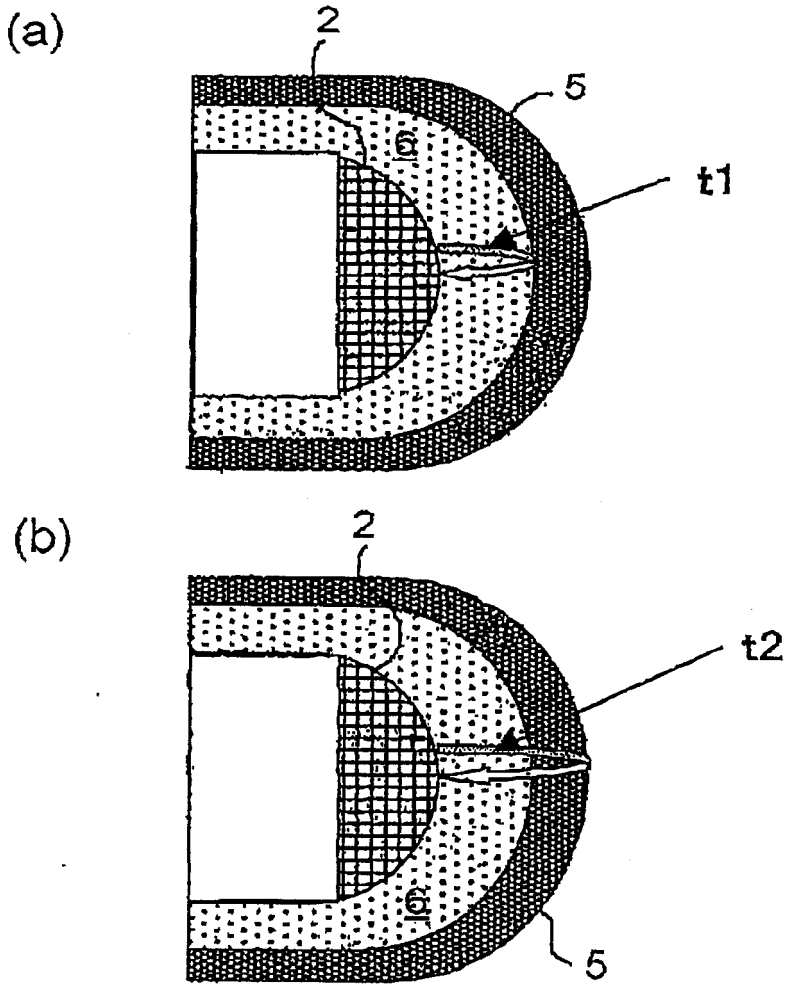
図2



【図３】


音速変化
2500
2000
1500
1000
500
0
音速
10
20
30
40
温度
ウィンドウ５
オイル６

【図４】


(a)
2
5
6
t1
(b)
2
t2
6
5

【書類名】　　要約書

【要約】

【課題】　温度センサを設けることなく、また、超音波出力を過度に低く設定することなく被検体接触面温度を所定値以下に制御する。

【解決手段】　オイル６を通過してウィンドウ５の内面により反射され、オイルを戻る反射時間ｔ１と、ウィンドウを通過してウィンドウの外面により反射され、ウィンドウ及びオイルを戻る反射時間ｔ２を検出し、

ウィンドウの音速＝（ウィンドウの厚み×２）／（ｔ２－ｔ１）

を計測し、この計測した音速からウィンドウの表面温度を検出する。

【選択図】　　図４

(TRANSLATION)

DOCUMENT 2

DATE OF SUBMISSION HEISEI 15 June. 20(2003)

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We have prepared a planned application draft including drawings as to the following APPLICATION REQUEST.
Please check the same.

※ Since the request sheet has not yet been received, please advise us of the IP unit and CODE No., and please check the name/address of the inventor on the petition.

[REQUEST] REQUESTING DEPARTMENT TO ARRIVE REQUEST NO. TO ARRIVE
REQUEST SHEET ☐ RECEIVED ☐ NOT RECEIVED

[DOCUMENT] 13 SHEETS (INCLUDING THIS SHEET) *RANK is not yet designated.*

[HANDLING MATTER]
APPLICATION DOCUMENT ☐ ATTACHED ☐ NOT ATTACHED
CONFIRMING THE CONTENTS ☐ CONFIRMED ☐ NOT CONFIRMED
CONFIRMING METHOD ☐ TEL· FAX ETC. ☐ INTERVIEW MEETING ETC.
CONPLEMENT CONTENTS ☐ YES ☐ NO
☐ SLIGHT MODIFICATION
☐ SUBSTANTIAL MODIFICATION/ CLAIM RECONSTRUCTION
☐ REWRITING/NEW MATTER ADDITION
EMERGENCY REQUEST ☐ YES ☐ NO
PREFERRED FILING DATE ☐ YES ( ) ☐ NO

[SPECIFIC FEE]

RANK AT REQUEST	RANK	NUMBER OF CLAIMS	ADDITIONAL FEE
	A RANK · B RANK	2	100,000

INTELLECTUAL GROUP ANSWER

【DOCUMENT NAME】 PATENT APPLICATION

【REFERENCE NUMBER】 290

【TO】 The Director-General of the Patent Office

【IPC】 A61B 8/00

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【INDICATION OF FEES】

【DEPOSIT LEDGER NUMBER】 039103

【AMOUNT OF PAYMENT】 ¥21,000

【LIST OF SUBMITTING ARTICLES】

【ARTICLE NAME】 Specification 1

【ARTICLE NAME】 Drawings 1

【ARTICLE NAME】 Abstract 1

【GENERAL POWER OF ATTORNEY No.】 0003222

[DOCUMENT NAME] SPECIFICATION

[TITLE OF THE INVENTION] ULTRASONIC DIAGNOSTIC APPARATUS

[SCOPE OF CLAIMS]

[CLAIM 1]

An ultrasonic diagnostic apparatus, comprising:

a sound velocity calculation means for calculating the sound velocity of ultrasonic waves based on the difference between the reflex time of ultrasonic wave reflected from the inner surface of a window in contact with a test subject and the reflex time of ultrasonic wave reflected from the outer surface of the window and the thickness of the window;

a temperature calculation means for calculating the temperature of the window based on sound velocity calculated by the sound velocity calculation means; and

an ultrasonic wave output control means for controlling ultrasonic wave output based on temperature calculated by the temperature calculation means.

[CLAIM 2]

An ultrasonic diagnostic apparatus, comprising:

a sound velocity calculation means for calculating the sound velocity of ultrasonic waves based on the reflex time of ultrasonic wave passing through fluid wherein sonic elements vibrate and reflected from the inner surface of a window in contact with a test subject and the thickness of the fluid;

a temperature calculation means for calculating the temperature of the fluid based on the sound velocity calculated by the sound velocity

calculation means; and

an ultrasonic wave output control means for controlling ultrasonic wave output based on temperature calculated by the temperature calculation means.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[TECHNICAL FIELD TO WHICH THE INVENTION PERTAINS]

The present invention relates to an ultrasonic diagnostic apparatus for controlling the test subject contact surface temperature of an ultrasonic probe.

[0002]

[PRIOR ART]

Because the surface of an ultrasonic probe comes into direct contact with the patient, legal regulations exist such that the surface is below a predetermined temperature (for example, 43°C) in order to avoid injury such as burns to the patient. As Prior Example 1, a method for controlling ultrasonic wave output by providing a temperature sensor within a probe, for example, is proposed, as shown in Patent Documents 1 and 2, below. In addition, as Prior Example 2, a method for controlling the applied voltage of a probe by software and hardware such that surface temperature does not exceed the regulation value by measuring the relation between the applied voltage of the probe and surface temperature beforehand, in place of providing a temperature sensor, for example, is proposed, as shown in Patent Reference 3, below.

[0003]

Patent Reference 1: Japanese Patent Application Publication No. H7-265315 (Fig. 1, Paragraph 0008)

Patent Reference 2: Japanese Patent Application Publication No. 2001-321377 (Fig. 1, Paragraph 0026)

Patent Reference 3: Japanese Patent Application Publication No. 2000-5165 (Fig. 1, Paragraph 0020)

[0004]

[ISSUES TO BE SOLVED BY THE INVENTION]

However, in the foregoing Prior Example 1 which uses temperature sensor, there is a problem in that it becomes more expensive due to the temperature sensor and, in addition, there is a problem in that the probe surface temperature, which is the test subject contact surface temperature, cannot be measured accurately depending on the arrangement position (Issue 1).

[0005]

In addition, in the foregoing Prior Example 2 wherein surface temperature is controlled by software and hardware, there is a problem in that the surface temperature sometimes exceeds regulation value due to bugs in the software, runaway software, hardware malfunction and the like. Furthermore, in practice, when ultrasonic waves are received consecutively, the surface temperature gradually rises according to the specific heat of the probe window or internal fluid, and even if the regulation value is not exceeded suddenly, there is a problem in that the sensitivity of ultrasound image is poor because ultrasonic wave output is set excessively low in Prior Example 2 (Issue 2).

[0006]

In light of the foregoing Issues 1 and 2, the object of the present invention is to provide an ultrasonic diagnostic apparatus which can hold the test subject contact surface temperature below a predetermined value without providing a temperature sensor or setting ultrasonic wave output excessively low, thereby preventing low-temperature burn injuries.

[0007]

[MEASURES FOR SOLVING THE ISSUES]

In order to achieve the foregoing object, the present invention comprises:

a sound velocity calculation means for calculating the sound velocity of ultrasonic waves based on the difference between the reflex time of ultrasonic wave reflected from the inner surface of a window in contact with the test subject and the reflex time of ultrasonic wave reflected from the outer surface of the window and the thickness of the window;

a temperature calculation means for calculating the temperature of the window, based on sound velocity calculated by the sound velocity calculation means; and

an ultrasonic wave output control means for controlling ultrasonic wave output, based on temperature calculated by the temperature calculation means.

Because the temperature of the window in contact with the test subject can be detected by the foregoing construction, the test subject contact surface temperature can be held below a predetermined value without providing a temperature sensor or setting ultrasonic wave output

excessively low, thereby preventing low-temperature burn injuries.

[0008]

In addition, in order to achieve the foregoing objective, the present invention comprises:

a sound velocity calculation means for calculating the sound velocity of ultrasonic waves based on the reflex time of ultrasonic wave passing through fluid wherein sonic elements vibrate and reflected from the inner surface of a window in contact with the test subject and the thickness of the fluid;

a temperature calculation means for calculating the temperature of the fluid based on the sound velocity calculated by the sound velocity calculation means; and

an ultrasonic wave output control means for controlling ultrasonic wave output based on temperature calculated by the temperature calculation means.

Because the temperature of the window can be detected by the foregoing construction, the test subject contact surface temperature can be held below a predetermined value without providing a temperature sensor or setting ultrasonic wave output excessively low, thereby preventing low-temperature burn injuries.

[0009]

[EMBODIMENTS OF THE INVENTION]

Descriptions are hereinafter given of the embodiments of the present invention with reference to the drawings.

Fig. 1(a) shows the internal configuration of an ultrasonic probe 1

according to the present invention when viewed from the side, and Fig. 1(b) shows the internal configuration of the ultrasonic probe 1 when viewed from the front. In Fig. 1(a) and Fig. 1(b), the ultrasonic probe 1 is connected to an ultrasonic diagnostic apparatus main unit 10, shown in Fig. 2, via cable such as to enable connection and detachment. In the inner part which is separated from the outer part by window 5 at the tip of the ultrasonic probe 1, an arc-shaped sonic element 2 is supported by an ultrasonic motor (M) 3 such as to enable back and forth rotation within oil 6 in the direction perpendicular to the arc direction. Ultrasonic motor 3 is driven by providing driving electrical power from the ultrasonic diagnostic apparatus main unit 10, shown in Fig. 2, via a two-phase transformer (T) 4. Then, as shown in Fig. 2, the output of sonic element 2 is transmitted to the ultrasonic diagnostic apparatus main unit 10, processed by an image processing section 11 into a three-dimensional image in the arc direction, scanning direction and depth direction of the sonic element 2, and this three-dimensional image is shown on monitor 13.

[0010]

Incidentally, the attribute of "temperature – sound velocity of polymethylpentene as window 5 and 1.3 butanediol as oil 6 is as shown in Table 1 and the graph in Fig. 3, below:

[0011]

(Table 1)

	10	20	30	40°C
Window 5	1984	1929	1870	1810m/s
Oil 6	1583	1555	1528	1498m/s

[0012]

In addition, if ultrasonic pulses are outputted from the sonic element 2 when the ultrasonic probe 1 is not touching the test subject, they pass through oil 6, are reflected by the inner surface of window 5, and returns via oil 6, as shown in Fig. 4(a), and therefore, are received by sonic element 2 after time t1 has passed from output. Furthermore, on the other hand, they pass through window 5, are reflected by the outer surface of window 5, and returns via window 5 or oil 6, as shown in Fig. 4(b), and therefore, are received by sonic element 2 after time t2 has passed from output.

[0013]

Consequently, sound velocity of window 5 = (thickness of window 5 x 2) / (t2 – t1) is measured by main system 14 within the ultrasonic diagnostic apparatus main unit 10, and the surface temperature of window 5 can be detected from this measured sound velocity with reference to a graph such as that shown in Fig. 3. Then, if this temperature exceeds the predetermined value, the output of ultrasonic waves can be terminated or reduced.

[0014]

In addition, in a three-dimensional device which rotates sonic element 2, such as this embodiment, oil 6 is agitated and there is little difference between the temperatures of window 5 and oil 6, and therefore, by measuring

sound velocity of oil 6 = (thickness of oil 6 x 2) / t1,

the surface temperature of widow 5 can be detected indirectly.

[0015]

Here, errors in measured temperatures occur due to dispersions between "thickness of window 5" and "thickness of oil 6". Therefore, by providing a memory which stores "thickness of window 5" and "thickness of oil 6," obtained by measuring the ultrasonic propagation time of window 5 and oil 6 for each ultrasonic probe 1, when the ultrasonic probe 1 is in an assembled state, under a certain temperature beforehand and performing calibration, within the ultrasonic probe 1 and calculating the sound velocity of ultrasonic waves based on the "thickness of window 5" and "thickness of oil 6" which are stored in this memory, errors in measured temperature due to dispersions between "thickness of window 5" and "thickness of oil 6" can be reduced and temperature detection of a higher accuracy can be performed.

[0016]

Although the detection of sound velocity and temperature is performed on the ultrasonic diagnostic apparatus main unit 10 side in the foregoing embodiment, it can also be performed on the ultrasonic probe 1 side, and in this case, the existing ultrasonic diagnostic apparatus main unit 10 side can have a fail safe function. In addition, although a three-dimensional ultrasonic diagnostic apparatus is given as an example in the foregoing embodiment, it can be applied to a two-dimensional ultrasonic diagnostic apparatus, as well. Here, if the temperature exceeds the predetermined value when the user is using a three-dimensional ultrasonic diagnostic apparatus in two-dimensional mode (ultrasonic motor 3 is in a stop-state), temperature rise can be controlled by agitating oil 6 by rotating ultrasonic motor 3, without stopping or reducing the output of ultrasonic

waves, and therefore, the amount of time in an high-output state can be extended.

[0017]

[ADVANTAGEOUS EFFECT OF THE INVENTION]

As described above, according to the invention of claim 1, because the temperature of the window which comes into contact with the test subject can be detected, the test subject contact surface temperature can be held below a predetermined value without providing a temperature sensor or setting ultrasonic wave output excessively low, thereby preventing low-temperature burn injuries.

Furthermore, according to the invention of claim 2, because the temperature of the window can be detected, the test subject contact surface temperature can be held below a predetermined value without providing a temperature sensor or setting ultrasonic wave output excessively low, thereby preventing low-temperature burn injuries.

[BRIEF DESCRIPTION OF THE DRAWINGS]

Fig. 1(a) is an internal configuration diagram of an ultrasonic probe according to the present invention when viewed from the side;

Fig. 1(b) is a an internal configuration diagram of the ultrasonic probe according to the present invention when viewed from the front;

Fig. 2 is a block diagram showing one embodiment of an ultrasonic diagnosis device according to the present invention;

Fig. 3 is a graph showing the "temperature – sound velocity" attributes of the window in Fig. 1 and oil;

Fig. 4(a) is a schematic diagram showing reflection due to the inner

surface of the window in Fig. 1(a) and 1(b); and

Fig. 4(b) is a schematic diagram showing reflection due to the outer surface of the window in Fig. 1(a) and Fig. 1(b).

[LEGEND OF REFERENCE SYMBOLS]

1 ULTRASONIC PROBE

2 SONIC ELEMENT

3 ULTRASONIC MOTOR (m)

4 TWO-PHASE TRANSFORMER (T)

5 WINDOW

6 OIL

10 ULTRASONIC DIAGNOSTIC APPARATUS MAIN UNIT

11 IMAGE PROCESSING SECTION

13 MONITOR

14 MAIN SYSTEM

[DOCUMENT NAME] ABSTRACT

[ABSTRACT]

[ISSUES]

It is aimed to hold the test subject contact surface temperature below a predetermined value without providing a temperature sensor or setting ultrasonic wave output excessively low.

[SOLVING MEASURES]

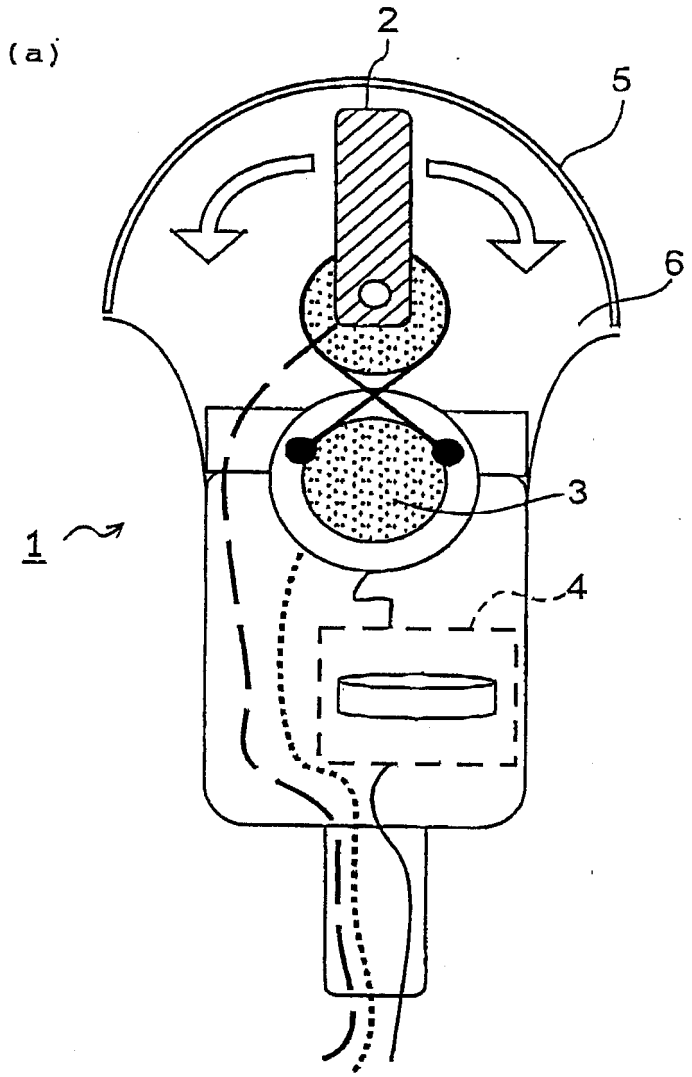
Reflex time t1, which passes through oil 6, is reflected by the inner surface of window 5, and is returned via oil, and reflex time t2, which passes through the window, is reflected by the outer surface of the window, and returned via window or oil, are detected,

sound velocity of window = (thickness of window x 2) / (t2 – t1)

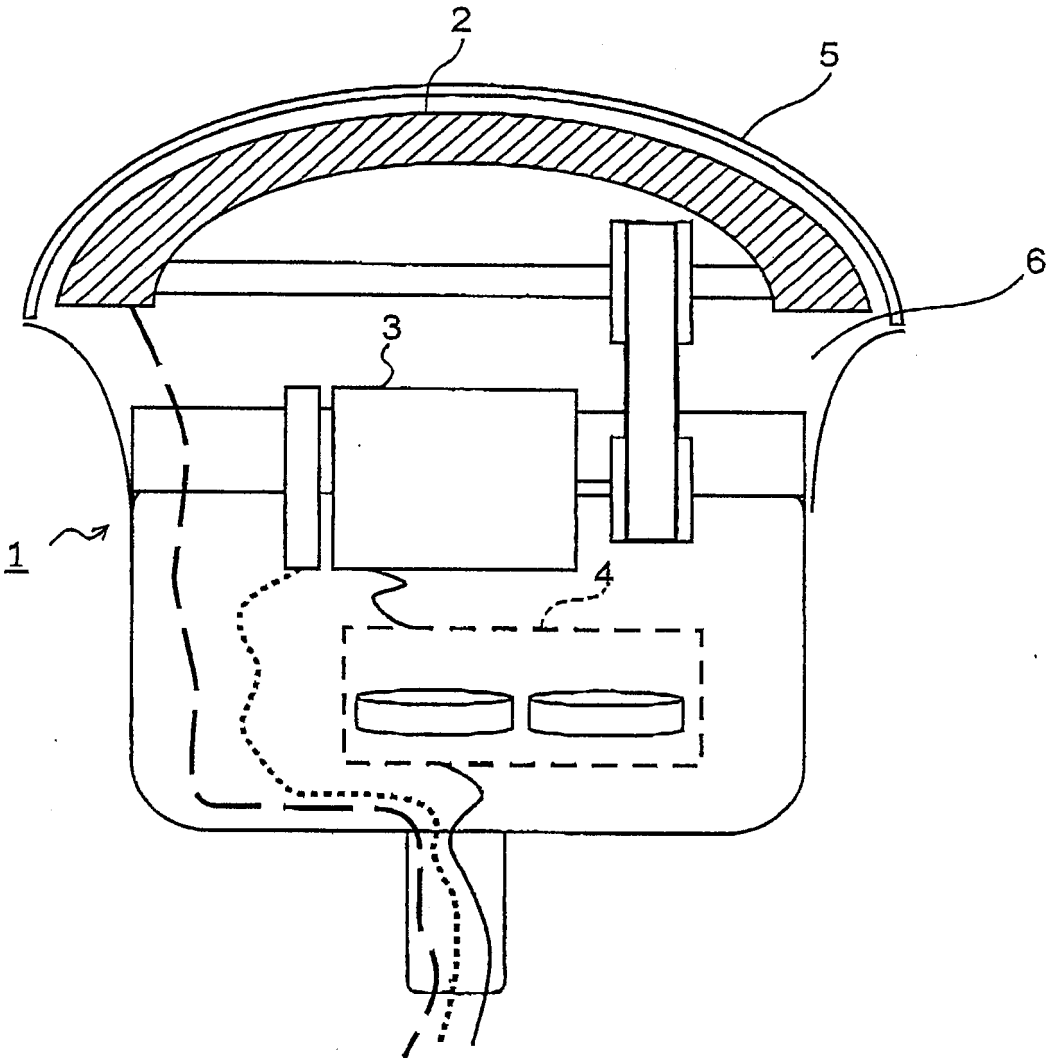
is measured, and the surface temperature of the window is detected from this measured sound velocity.

[SELECTED DRAWING] Fig. 4

FIG. 1



(b)



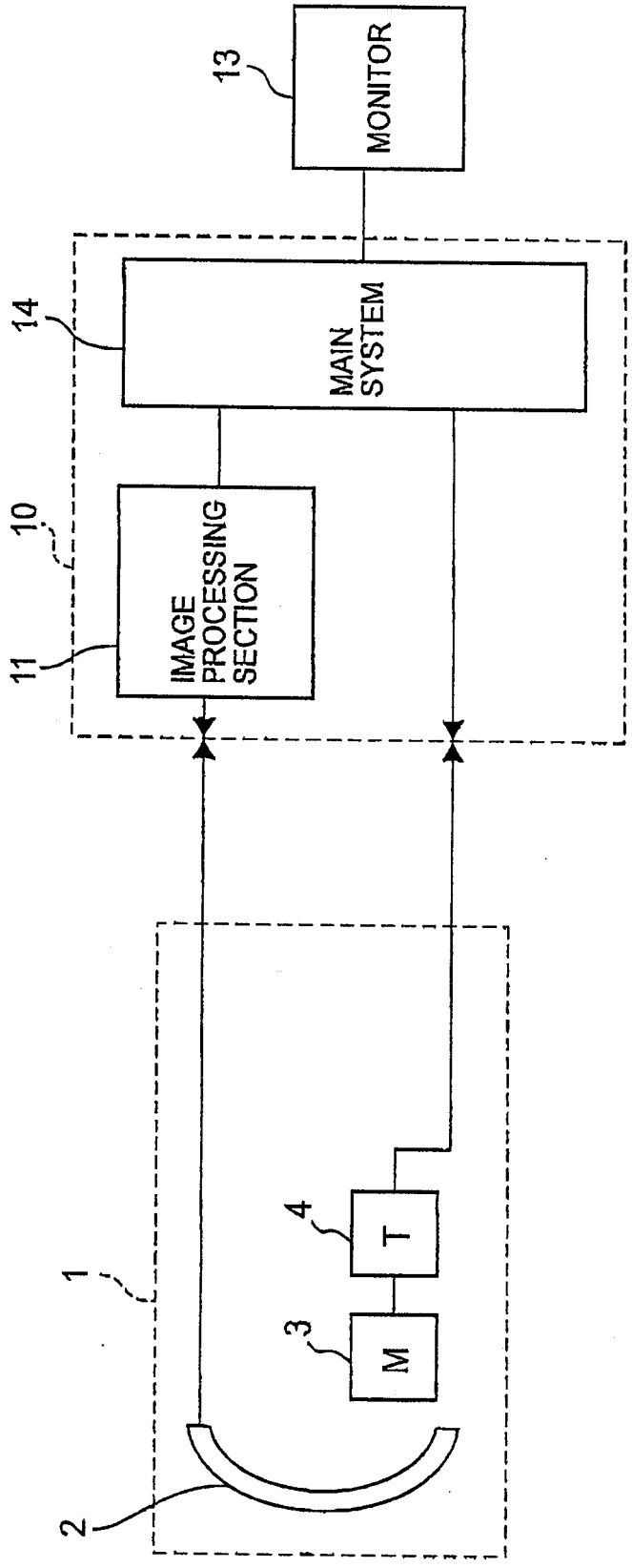

13
MONITOR
14
MAIN SYSTEM
10
11
IMAGE PROCESSING SECTION
1
4
T
3
M
2

FIG. 2

FIG. 3

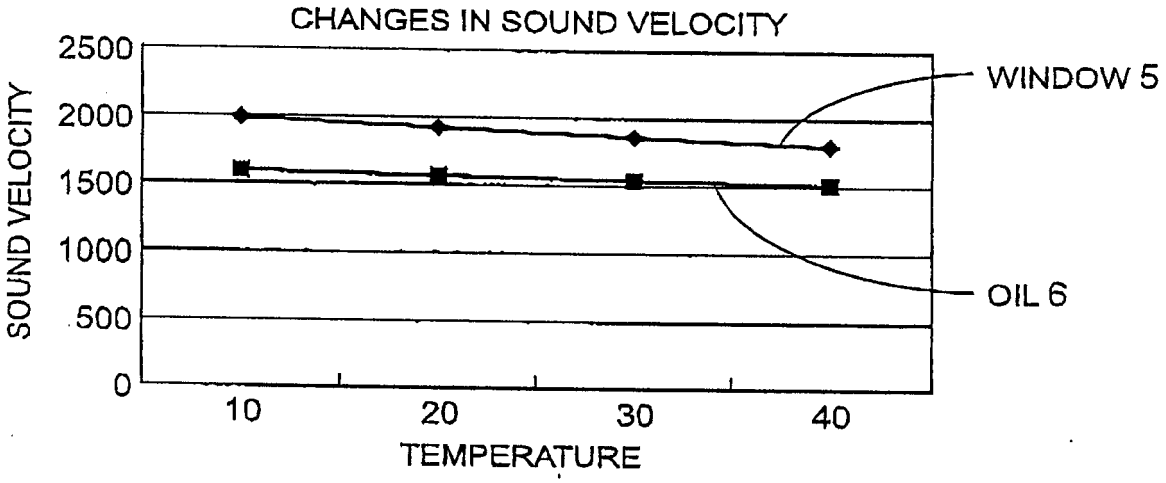
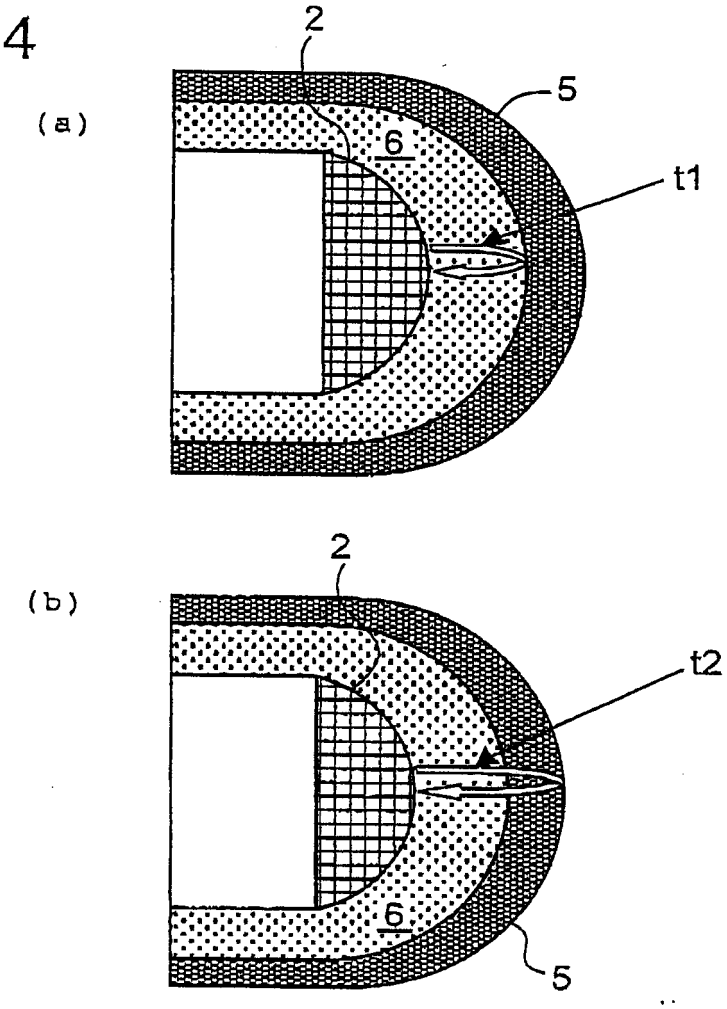

CHANGES IN SOUND VELOCITY
SOUND VELOCITY
2500
2000
1500
1000
500
0
10
20
30
40
TEMPERATURE
WINDOW 5
OIL 6

FIG. 4


(a)
2
5
6
t1
(b)
2
t2
6
5

VERIFICATION OF A TRANSLATION

I, the below named translator, hereby declare that:

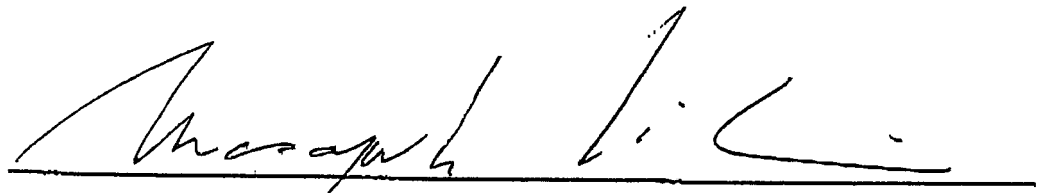
My name and post office address are stated below:

That I am knowledgeable in the English and Japanese languages and that I believe the followings include a true and complete translation into the English language of a draft of a patent application including a petition, a specification, drawings and an abstract, and a true and extracted translation into the English language of a transmittal letter dated June 20, 2003 from our firm to our client.

Signed this 5th day of July, 2007

Masayuki Nihei

Full name of Translator



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